

IDENTIFICATION OF LABORATORY MODEL AMIRA DR300

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Abstract

The main purpose of this paper is an experimental identification of a laboratory model AMIRA DR300, which is made by a company Amira from Duisburg in SRN. This model consists of two engines, which should be equal according to producer, but it was found by experiments, that this fact is not true. This finding led to need of the particular identification of both engines. These engines were identified by a least square method by a response of the output signal on a pseudorandom binary input signal. The programming system MATLAB/SIMULINK and the Real Time Toolbox were used for the identification experiment.

1 Description of laboratory a model AMIRA DR300

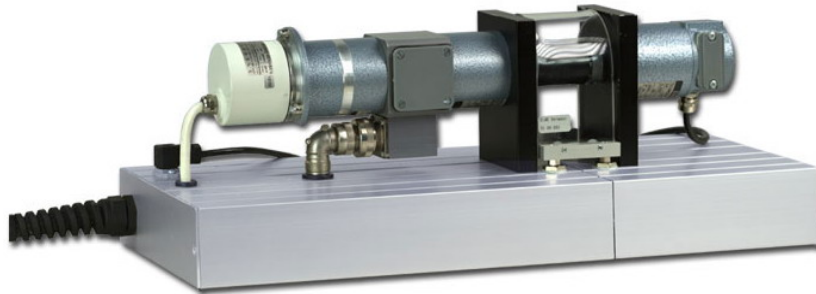


Figure 1: The laboratory model AMIRA DR300

The laboratory model AMIRA DR300 made by the company Amira from Duisburg in SRN presents a nonlinear one-dimensional system with a measurable disturbance value, which can be used for the identification, design and verification of control algorithms in real-time and in laboratory environment.

The laboratory model consists of two main parts. The first part is the mechanism itself (see at a Fig. 1) and the second part is a transmission housing.

The mechanism consists of two engines whose shafts are connected by a shaft coupling. The first one is a direct-current motor. Its input signal is a controllable voltage u , and output signal is a shaft speed ω , which is measured either by tachometer generator, or by an incremental position sensor. The second one serves as a generator and it is possible to use it as a source of the faulty measured value [2].

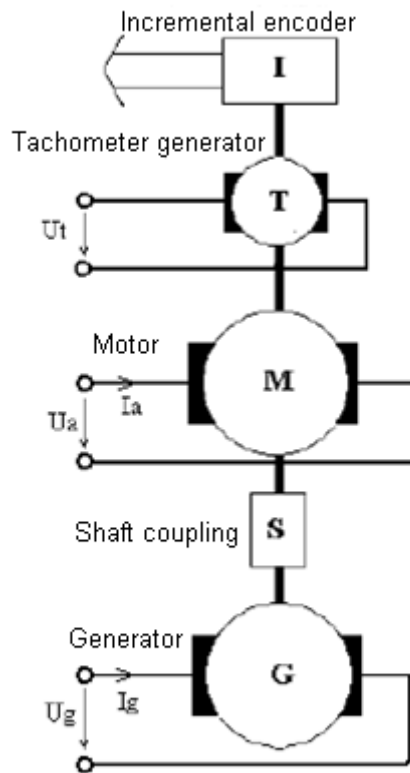


Figure 2: A model diagram

2 The identification of the motor

A static characteristic was measured in the first step because of a linear area selection, which is important for the next steps of the identification.

Response course of the tachometer generator's voltage on the controllable input voltage of the motor, which was measured by Real Time Toolbox, is shown at the Fig. 3.

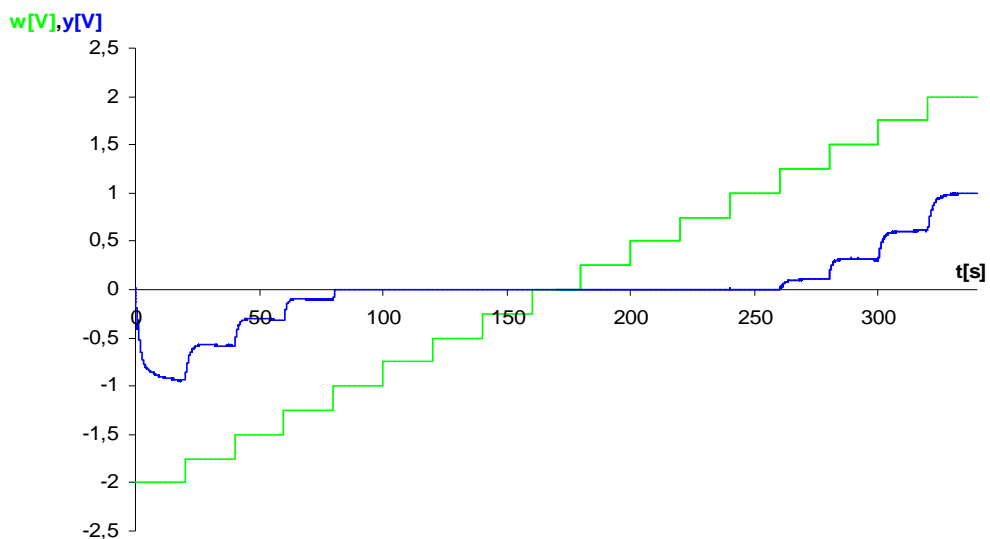


Figure 3: The time process of the static characteristics measurement on the motor

The final characteristic was obtained by an individually average of values of the output signal $y(t)$ in all steps of the reference signal $w(t)$. This was made in MATLAB/SIMULINK. The accomplishment of the final characteristic is shown at Fig. 4.

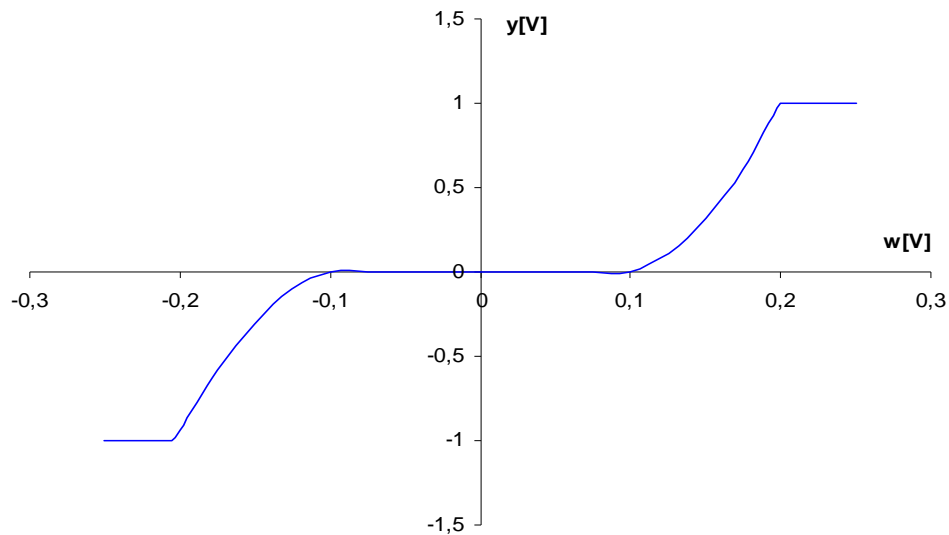


Figure 4: The final static characteristic of the motor

As the next step the pseudorandom binary input signal [1], [3] was created in MATLAB/SIMULINK with following parameters:

- UL - upper limit of the signal - $UL = 1.8V$
- LL - lower limit of the signal - $LL = 1.4V$
- Δt - clock pulse interval - $\Delta t = T = 0.05s$,

where:

- T - sampling time of the laboratory model AMIRA DR300,
- n - degrees count of a shift register - $n = 6$.

Upper and lower limits are selected by the linear area of the static characteristic.

The response of the system on this pseudorandom binary input signal is shown at Fig. 5.

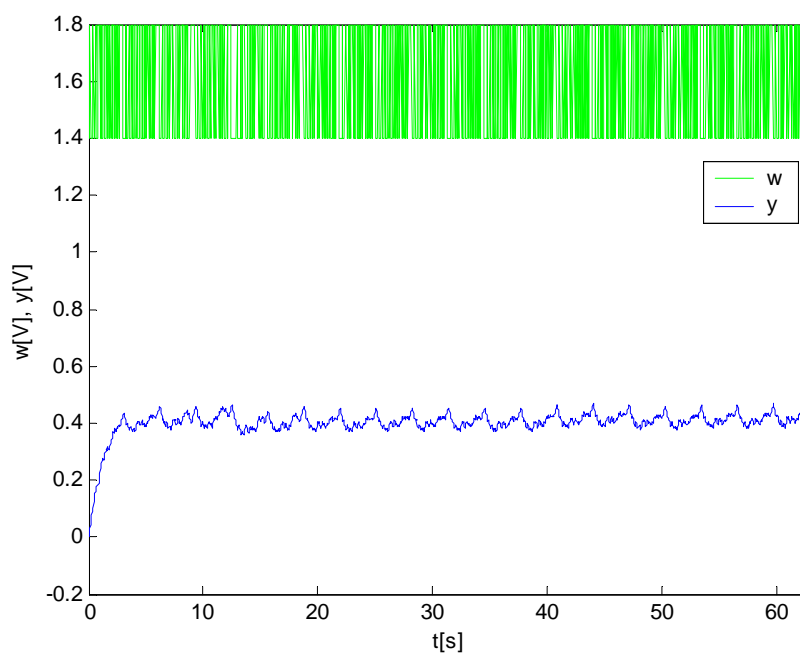


Figure 5: The response of the motor on the pseudorandom binary input signal

Parameters of the system were established from that response by the recursive least square method [1], [3] by program in MATLAB/SIMULINK and those parameters are shown below.

$$\begin{aligned}
 - a_0 &= 1 & - b_0 &= 0 \\
 - a_1 &= -1.0945 & - b_1 &= -0.0722 \\
 - a_2 &= 0.1717 & - b_2 &= 0.2691
 \end{aligned}$$

$$- G_s(z^{-1}) = \frac{-0.0722z^{-1} + 0.2691z^{-2}}{1 - 1.0945z^{-1} + 0.1717z^{-2}}$$

Comparison of responses between real and identified system is shown at Fig. 6.

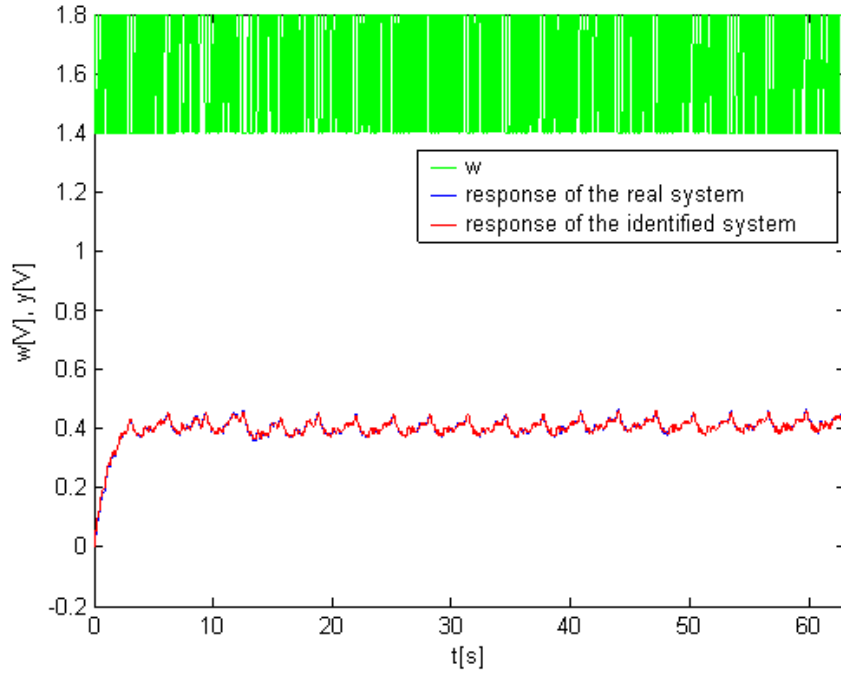


Figure 6: The responses comparison of the motor

These two processes were compared by quadratic criterion of difference of responses given by following equation

$$S_y = \sum_{i=1}^N (y_r(i) - y_i(i))^2 \quad (1)$$

and the criterion of identification quality

$$S_{ID} = \frac{1}{b-a+1} \sum_{k=a}^b [\hat{e}(k)]^2 \quad (2)$$

where:

- y_r - is the response of the real system,
- y_i - is the response of the identified system,
- a - is the initial step of the identification,
- b - is the final step of the identification [2].

These comparisons are shown in Table 1.

Table 1: Values of criterions S_y and S_{ID} of the motor

S_y	S_{ID}
0.0119	$1.4134 \cdot 10^{-5}$

3 The identification of the generator

The procedure of the identification was similar as in the previous case, but there is a need of the initial voltage on the motor, because shaft is not rotate without it. Two static characteristics and figures of responses were measured, because of finding relation between these responses on difference values of initial voltage.

Response courses of the tachometer generator's voltage on the controllable input voltage of the generator on difference input values of motor are shown at the Fig. 7 and Fig. 8.

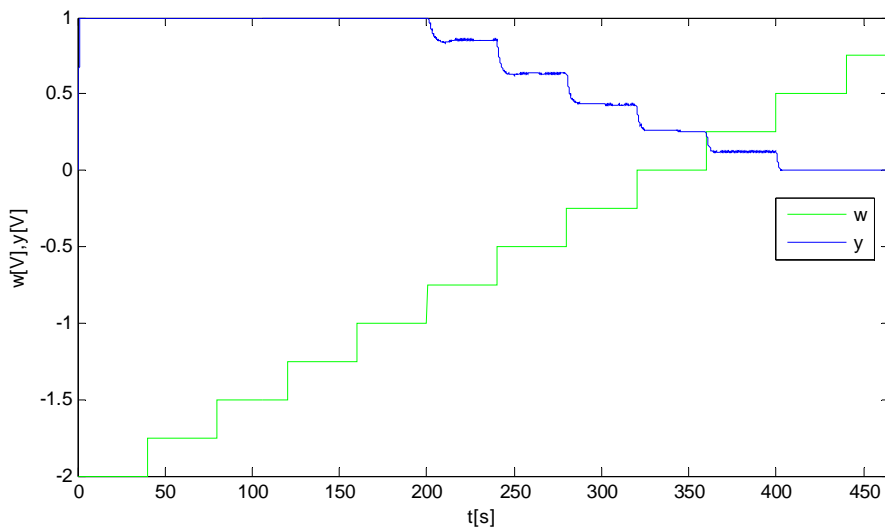


Figure 7: The time process of the static characteristics measurement of the generator when input value of the motor is 1.3V

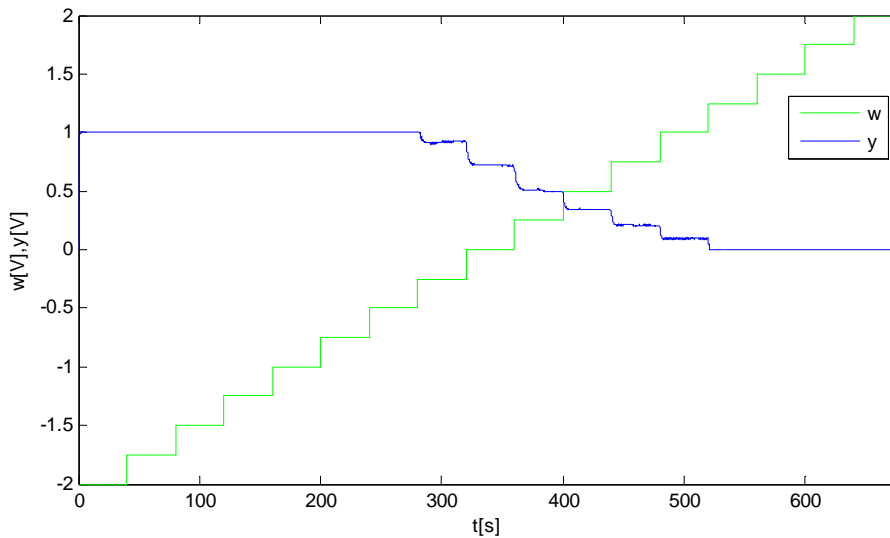


Figure 8: The time process of the static characteristics measurement of the generator when input value of the motor is 1.7V

Final characteristics were obtained by an individually average of values of the output signal $y(t)$ in all steps of the reference signal $w(t)$ in both cases. These accomplishments are shown at Fig. 9.

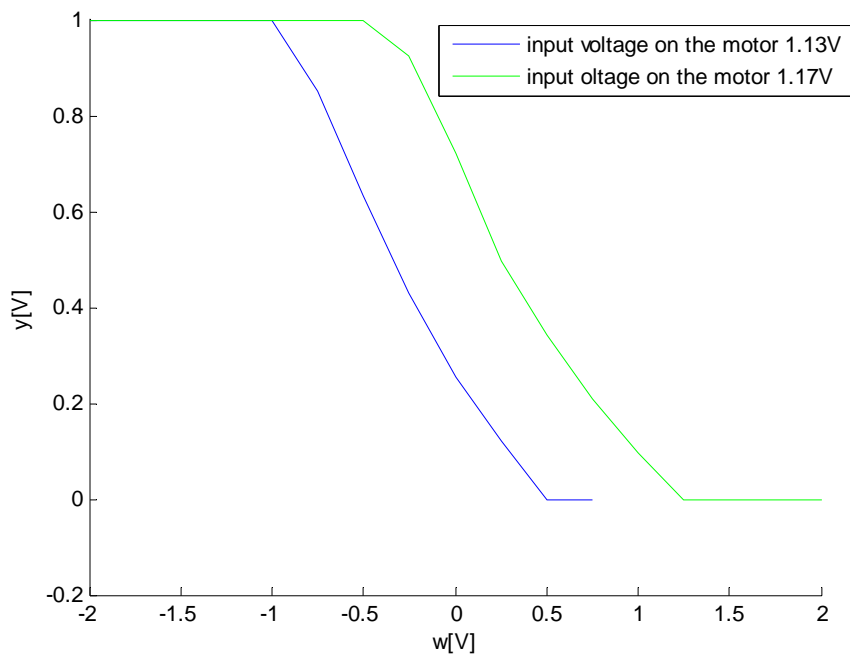


Figure 9: The final static characteristics of the generator

The pseudorandom binary input signal had same properties except UL and LL , which were set to $UL = 0.25V$ and $LL = 0V$. Both responses were subtracted in purpose of investigation if they are in linear or in other relation. The final responses and their difference are shown at Fig. 10.

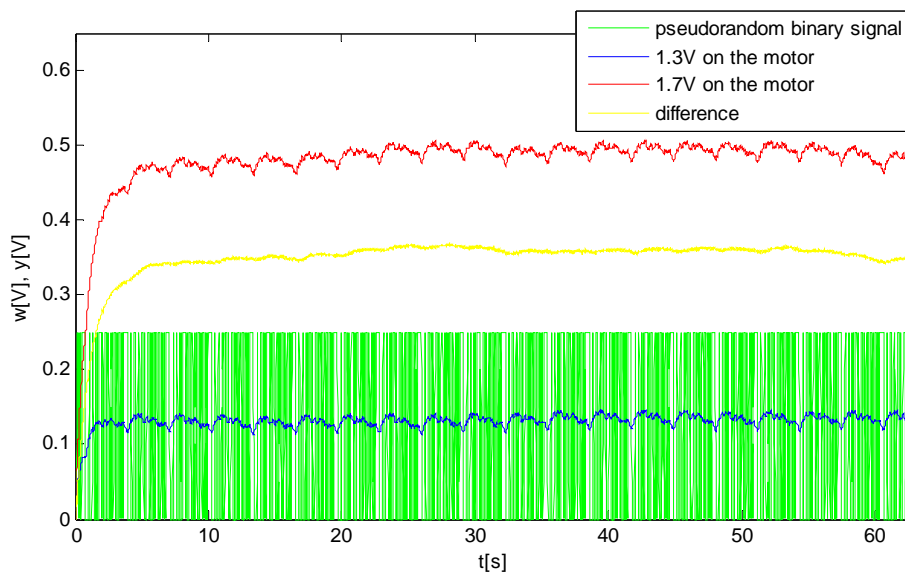


Figure 10: Responses of the generator on the pseudorandom binary input signal

At Fig. 10 it can be seen that these responses are almost in linear relation, thus any response of those can be used for identification. Parameters of the system were established from the response with 1.7V on motor by the recursive least square method and they are shown below.

- $a_0 = 1$
- $a_1 = -0.7488$
- $a_2 = -0.2524$
- $b_0 = 0$
- $b_1 = 0.0282$
- $b_2 = -0.0731$

$$- G_s(z^{-1}) = \frac{0.0282z^{-1} - 0.0731z^{-2}}{1 - 0.7488z^{-1} - 0.2524z^{-2}}$$

Comparison of responses between the real and the identified system on the pseudorandom binary input signal is shown at Fig. 11.

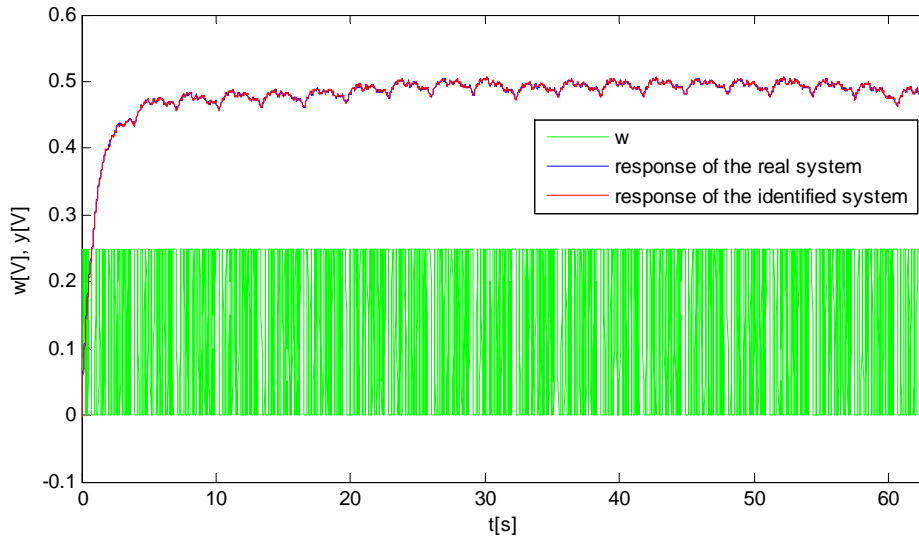


Figure 11: The responses comparison of the generator

These two processes were compared by criteria (1) and (2) and results are shown in Table 2.

Table 2: Values of criteria S_y and S_{ID} of the generator

S_y	S_{ID}
0.0083	$1.7796 \cdot 10^{-6}$

4 Results

Transfer functions $G_s(z^{-1}) = \frac{-0.0722z^{-1} + 0.2691z^{-2}}{1 - 1.0945z^{-1} + 0.1717z^{-2}}$ and $G_s(z^{-1}) = \frac{-0.0722z^{-1} + 0.2691z^{-2}}{1 - 1.0945z^{-1} + 0.1717z^{-2}}$ were established by partial experimental identification of both engines. Responses of these transfer functions on pseudorandom binary signal were compared with responses of the real system on the same signal by criteria, which values are shown in Table 3.

Table 3: Values of criteria S_y and S_{ID} of the motor and the generator

Motor		Generator	
S_y	S_{ID}	S_y	S_{ID}
0.0119	$1.4134 \cdot 10^{-5}$	0.0083	$1.7796 \cdot 10^{-6}$

References

- [1] Bobál, V., Chalupa, P., Novák, J., Dostál, P. Adaptive control of nonlinear servo system: comparison of standard and dual approaches. In: Proc. of the 26th IASTED International Conference on Modelling, Identification and Control, Innsbruck, Austria, 2007, 414-419.
- [2] Hubáček, J. Prediktivní řízení s omezením vstupních a výstupních veličin. Master thesis, UTB FAI, 2008.
- [3] Bobál, V., Kubalčík, M., Chalupa, P., Dostál, P. Adaptive predictive control of nonlinear system with constraint of manipulated variable. In: Proc. of the 28th IASTED International Conference on Modelling, Identification and Control, Innsbruck, Austria, 2009, 349-354.

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